Earth Science
&
Technology Directorate

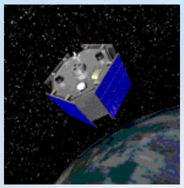
Presentation to
Flight Opportunities
Program

Tony Freeman
May 2012

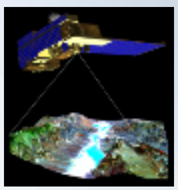
JPL Earth Science Flight Projects

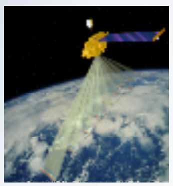
Operational

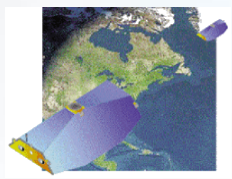

QuikSCAT
(1999)


ACRIMSAT
(1999)


Jason-1
(2001)


ASTER
(1999)

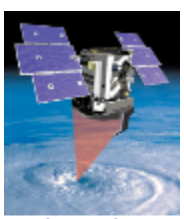

MISR
(1999)


GRACE
(2002)

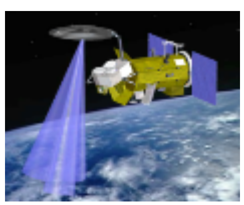

AIRS
(2002)


TES
(2004)

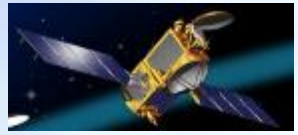

MLS
(2004)

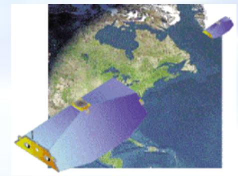

CloudSat
(2006)


Ocean Surface
Topography Mission
(2008)


Sea Surface
Salinity: Aquarius
(2011)

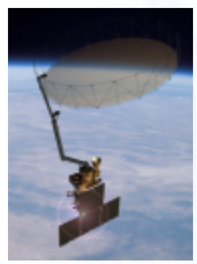
Formulation/Development

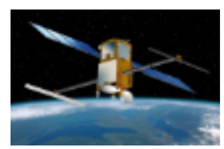

Jason 3*
(2014)

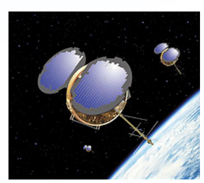

GRACE-FO
(2017)


Carbon Cycle: OCO-2
(2013)


DESDynI
(TBD)

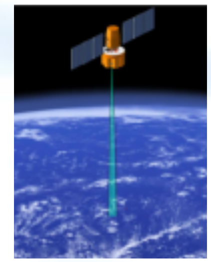

Soil Moisture: SMAP
(2014)


SWOT
(2019)

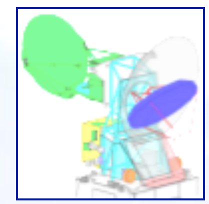

COSMIC-2*
(2014)

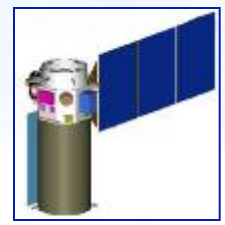

OCO-3
(NLT 2015)

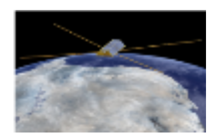
Mission Studies

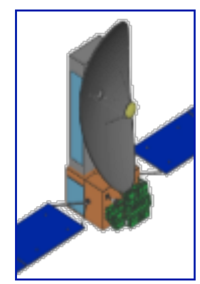

ASCENDS CO_2
(2020)


HyspIRI


Ocean Vector
Winds


GEO-CAPE

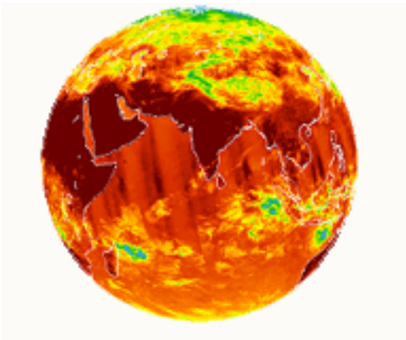

Venture
Missions/
Instruments


PACE
(2020)

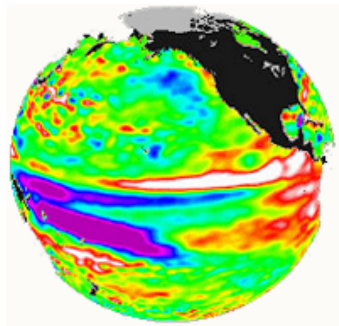
*NOAA

Change from 2010

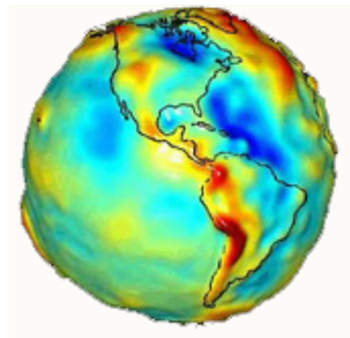
JPL's Earth Science Observations



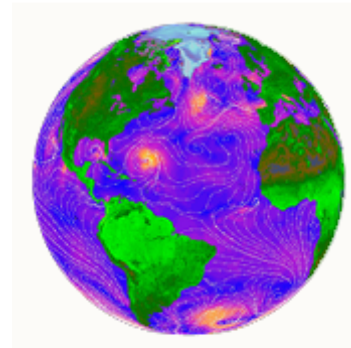
Atmospheric Infrared Sounder **(AIRS)** provides monthly global temperature maps



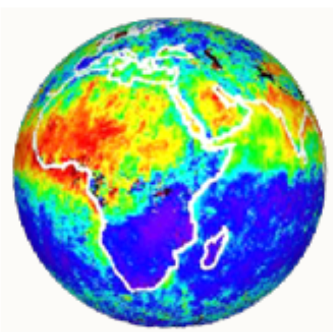
Jason provides global sea surface height maps every 10 days



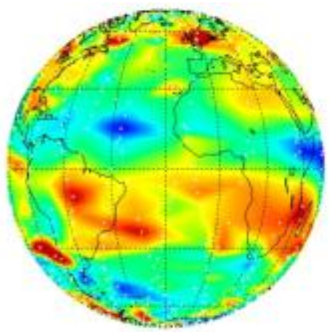
Gravity Recovery and Climate Experiment **(GRACE)** provides monthly maps of Earth's gravity



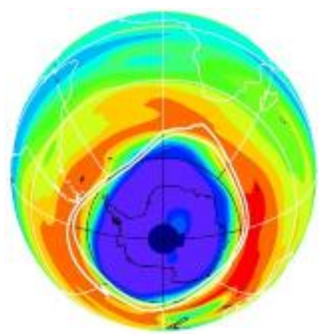
Quikscat collects data over the polar regions, and supports Cal/Val of India's Oceansat-2



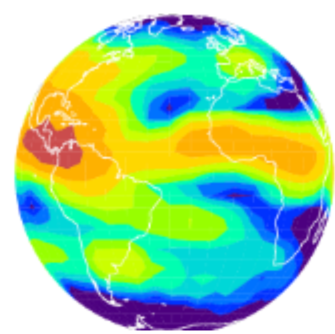
Multi-angle Imaging Spectro Radiometer **(MISR)** provides monthly global aerosol maps



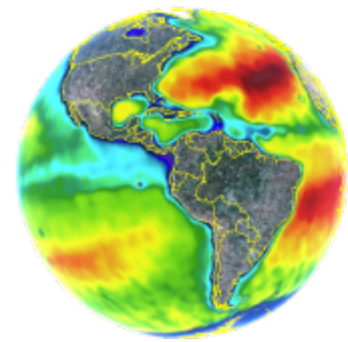
Tropospheric Emission Spectrometer **(TES)** provides monthly global maps of Ozone



Microwave Limb Sounder **(MLS)** provides daily maps of stratospheric chemistry

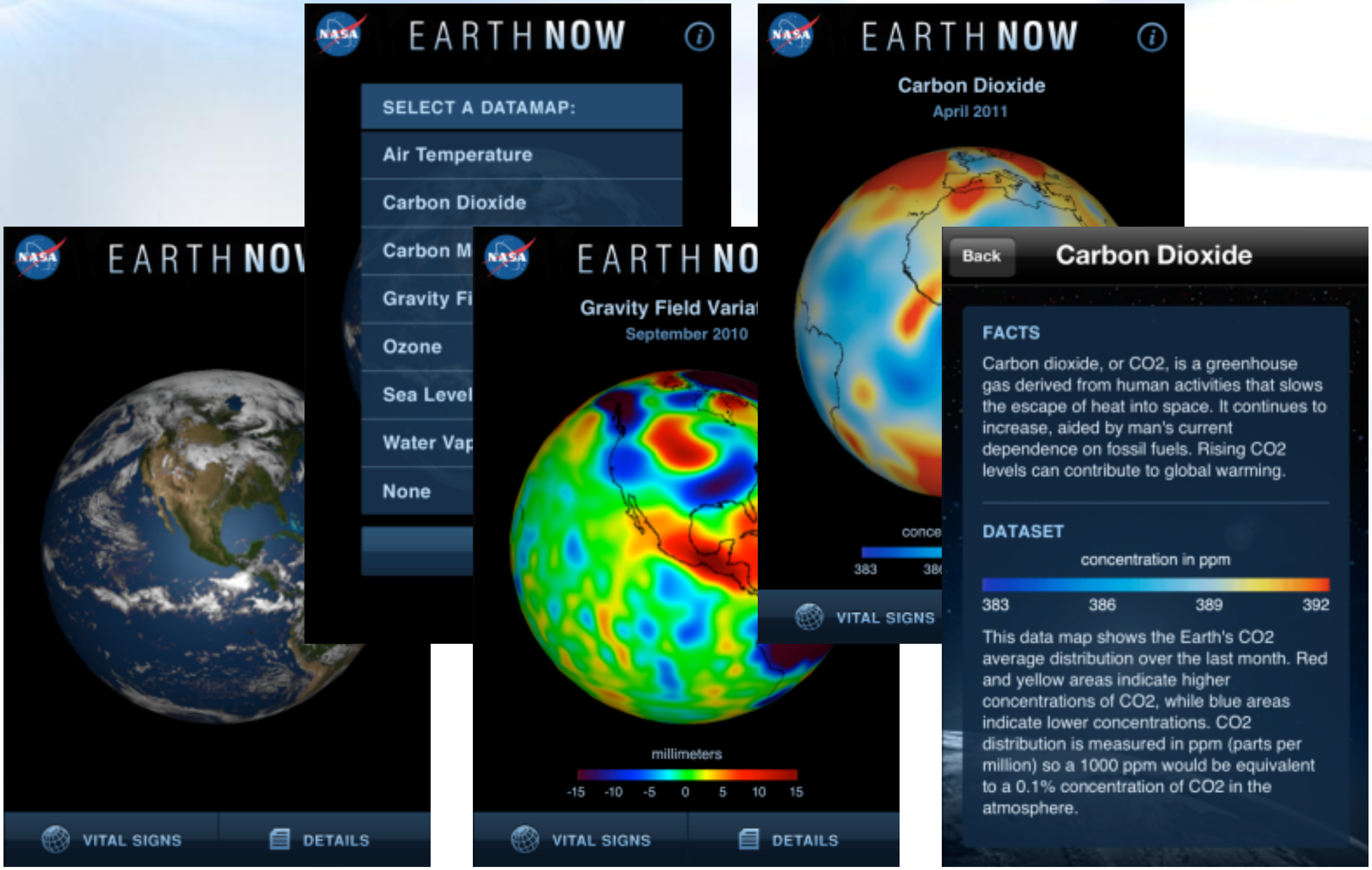


CloudSat provides monthly maps of cloud ice water content



Aquarius provides monthly maps of sea surface salinity

EARTHNOW iPhone App



Http://jplmobile.jpl.nasa.gov/

JPL Earth Science Instrument Incubator (IIP) Tasks

Task Title	JPL PI (or Lead)	Targeted Mission(s)
Shortwave Infrared Polarimetric Imager for Aerosol and Cloud Remote Sensing	Diner, David	PACE, ACE
A Multi-parameter Atmospheric Profiling Radar for ACE (ACERAD)	Durden, Steve	ACE
Laser Ranging Frequency Stabilization Subsystem for GRACE II	Folkner, Bill	GRACE-II
Ka-band SAR Interferometry Studies for the SWOT Mission	Fu, Lee	SWOT
HyTES: A Hyperspectral Thermal Emission Spectrometer for HyspIRI-TIR Science	Hook, Simon	HyspIRI
GeoSTAR technology development and risk reduction for PATH	Lambrigtsen, Bjorn	PATH
Panchromatic Fourier Transform Spectrometer (PanFTS) Instrument for the Geostationary Coastal and Air Pollution Events (GEO-CAPE) Mission	Sander, Stan	GEO-CAPE
A Scanning Microwave Limb Sounder for Studying Fast Processes in the Troposphere	Stek, Paul	GACM
A Deployable 4-meter 180 to 680 GHz Antenna for the Scanning Microwave Limb Sounder	Cofield, Richard	GACM
Aircraft Deployable UV-SWIR Multiangle Spectropolarimetric Imager	Diner, David	PACE, ACE
The Prototype HyspIRI Thermal Infrared Radiometer (PHyTIR) for Earth Science	Hook, Simon	HyspIRI
Development of an Internally-Calibrated Wide-Band Airborne Microwave Radiometer to Provide High-Resolution Wet-Tropospheric Path Delay Measurements for SWOT	Kangaslahti, Pekka	SWOT
Risk Reduction for the PATH Mission	Lambrigtsen, Bjorn	PATH
AirSWOT and Critical Technologies for the SWOT Mission	Rodriguez, Ernesto	SWOT
Panchromatic Fourier Transform Spectrometer Engineering Model (PanFTSEM) Instrument for the Geo-CAPE Mission	Sander, Stan	GEO-CAPE
Atomic Gravity Gradiometer for Earth Gravity Mapping and Monitoring Measurements	Yu, Nan	GRACE 3rd-Generation

IIP-2007   IIP-2010

JPL Earth Science Advanced Component Technology (ACT) Tasks

Task Title	JPL PI (or Lead)	Targeted Mission(s)
Advanced Component Development to Enable Low-Mass, Low-Power High-Frequency Radiometers for Coastal Wet-Tropospheric Correction on SWOT	Brown, Shannon	SWOT
A Low Power, High Bandwidth Receiver for Ka-band Interferometry	Esteban-Fernandez, Dani	SWOT
Advanced Thermal Packaging Technologies for RF Hybrids	Hoffman, Jim P.	DESDynI
A Large High-Precision Deployable Reflector for Ka- and W-band Earth Remote Sensing	Lane, Marc	ACE
A GNSS RF ASIC For Digital Beamforming Applications	Meehan, Tom	TriG, GPSRO
In-Pixel Digitization Read Out Integrated Circuit for the Geostationary Coastal and Air Pollution Events (GEO-CAPE) Mission	Rider, David	GEO-CAPE
CLASS Instrument Technology Maturation for ASCENDS	Spiers, Gary	ASCENDS
Large Deployable Ka-Band Reflect Array for the SWOT Mission	Thomson, Mark	SWOT
Precision Deployable Mast for the SWOT KaRin Instrument	Agnes, Greg	SWOT
Advanced Amplifier Based Receiver Front Ends for Submillimeter-Wave Sounders	Chattopadhyay, Goutam	GACM
High Power Mid-IR Laser Development 2.8-3.5 um	Forouhar, Siamak	ASCENDS
Advanced W-Band Gallium Nitride Monolithic Microwave Integrated Circuits (MMICs) for Cloud Doppler Radar Supporting ACE	Fung, Andy	ACE
High Efficiency, Digitally Calibrated TR Modules Enabling Lightweight SweepSAR Architectures for DESDynI-Class Radar Instruments	Hoffman, Jim	DESDynI
Development of Immersion Gratings to Enable a Compact Architecture for High Spectral and Spatial Resolution Imaging	Kuhnert, Andreas	Next-Gen Spectrometers
A 2-micron Pulsed Laser Transmitter for Direct Detection Column CO2 Measurement from Space	Menzies, Bob	ASCENDS

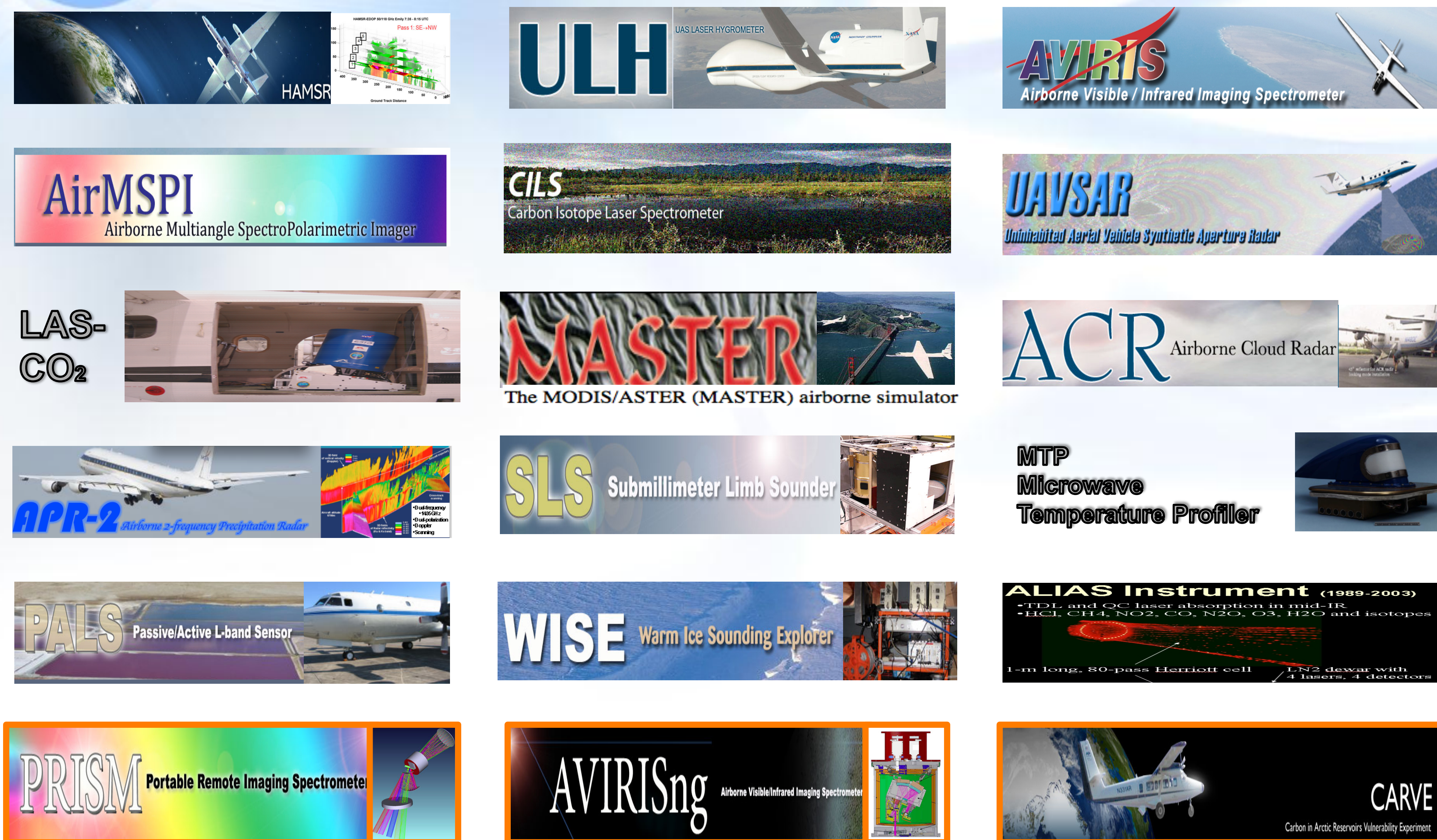
ACT-2008 ACT-2010

JPL Earth Science Advanced Information Systems Technology (AIST) Tasks

Task Title	JPL PI (or Lead)	Targeted Mission(s)
Geostatistical Data Fusion for Remote Sensing Applications	Braverman, Amy	ASCENDS
Sensor Web 3G to provide Cost-Effective Customized Data Products for Decadal Mission	Chien, Steve	SMAP, HyspIRI
QuakeSim: Increasing Accessibility and Utility of Spaceborne and Ground-based Earthquake Fault Data	Donnellan, Andrea	DESDynI
Onboard processing and autonomous data acquisition for the DESDynI mission	Lou, Yunling	DESDynI
OSCAR: Online Services for Correcting Atmosphere in Radar	Paul Von Allmen, Paul	DESDynI
On-Board Processing to Optimize the MSPI Imaging System for ACE	Pingree, Paula	ACE
InSAR Scientific Computing Environment	Rosen, Paul	DESDynI
Moving Objects Database Technology for Weather Event Analysis and Tracking	Talukder, Ashit	PATH, 3D-Winds
Instrument Simulator Suite for Atmospheric Remote Sensing	Tanelli, SImone	ACE
Real-Time In-Situ Measurements for Earthquake Early Warning and Space-Borne Deformation Measurement Mission Support	Webb, Frank	DESDynI
Multivariate Data Fusion and Uncertainty Quantification for Remote Sensing	Braverman, Amy	ASCENDS
QuakeSim: Multi-Source Synergistic Data Intensive Computing for Earth Science	Donnellan, Andrea	DESDynI
Advanced Rapid Imaging & Analysis for Monitoring Hazards	Hook Hua, Hook	DESDynI
Fusion of Hurricane Models and Observations: Developing the Technology to Improve the Forecasts	Hristova-Veleva, Svetla	PATH
Next-Generation Real-Time Geodetic Station Sensor Web for Natural Hazards Research and Application	Kedar, Sharon	DESDynI
Integration of the NASA CAMVis and Multiscale Analysis Package (CAMVis-MAP) for Tropical Cyclone Climate Study	Li, Frank	ACE, PATH, 3D-Wind
On-Board Processing to Advance the PanFTS Imaging System for GEO-CAPE	Pingree, Paula	GEO-CAPE
Plume Tracer: Interactive Mapping of Atmospheric Plumes via GPU-Based Volumetric Ray Casting	Realmuto, Vincent	HyspIRI
Unified Simulator for Earth Remote Sensing	Tanelli, SImone	SMAP, SCLP, SWOT

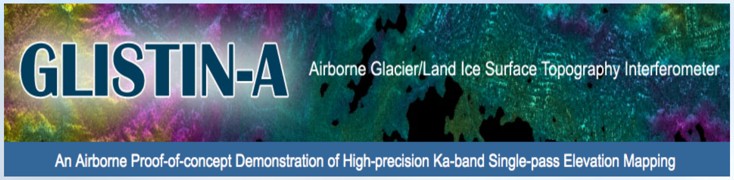
AIST-2008   ACT-2011

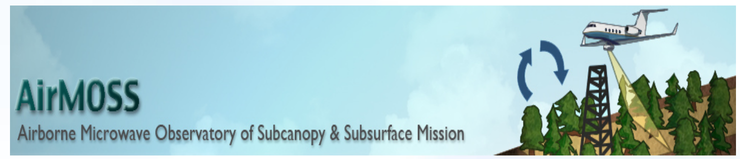
Airborne Instruments (Operational)

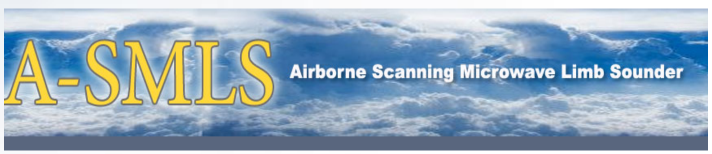


http://airbornescience.jpl.nasa.gov

Airborne Instruments (Development)







- AirMOSS, GLISTIN-A, HyTES, A-SMLS, AirSWOT fly in 2012
- AirMSPI-2 flies in 2014

GRIFEX: GEO-CAPE Read Out Integrated Circuit (ROIC) In-Flight Performance Experiment

PI: David Rider, JPL

Objective

• Spaceborne performance verification of a state-of-the-art ROIC/FPA with unprecedented frame rate of 16 kHz for imaging interferometry instruments and missions including GEO-CAPE.

• Assess functionality and data integrity of ROIC through engineering measurements.

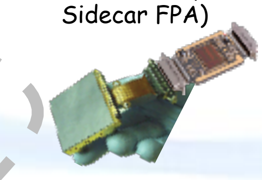
• Advance GEO-CAPE PanFTS ROIC to TRL 7.

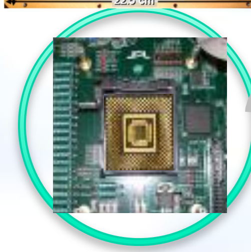
• Enable this key technology for high spectral resolution measurements of atmospheric composition from geostationary orbit and other vistas.

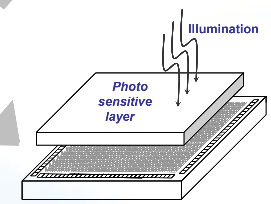
Radio Aurora Explorer (RAX) 3U baseline bus for GRIFEX

Current generation FPA (OCO FPA)

Next generation FPA (JWST Teledyne Sidecar FPA)







State-of-the-Art In-pixel digitization FPA

Spaceborne validation of In-Pixel ADC ROIC/FPA for GEO-CAPE, and other missions, represents a significant advance over previous technologies with an unprecedented throughput of 4.2 Gbits/s

Approach

• Develop 3U cubesat with high frame rate camera, UHF and/or S-band radio (1Mb/s), and active magnetic stabilization for integration of the JPL ROIC/FPA and imaging detector payload.

• Manifest the flight with NASA Launch Services for 2013 LEO high inclination, or GEO, launch opportunities.

• Downlink and verify noise and imaging performance for Earth remote sensing in the space environment.

Co-Is/Partners:

James Cutler, U. Michigan; Paula Pingree, JPL

Key Milestones

• Parts procurement and hybridization of ROIC with detector material by Raytheon Vision Systems	09/11
• Demonstrate Hybrid FPA in lab environment	12/11
• Complete engineering model of JPL payload board and U. Michigan 3U CubeSat design	03/12
• Complete integration and testing of full-up GRIFEX engineering model (EM)	06/12
• Deliver flight model (FM) of JPL payload board	09/12
• Complete GRIFEX flight unit and system test	12/12
• Perform integration and deliver analysis software	03/13

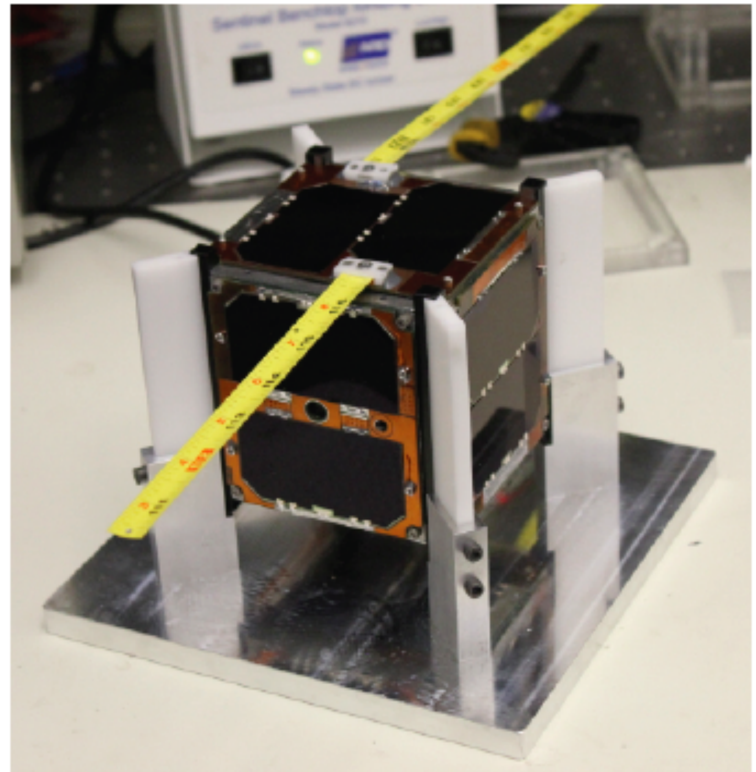
$\mathbf{TRL_{in} = 4}$

JPL/U. Michigan Collaboration

Jet Propulsion Laboratory
California Institute of Technology

M-Cubed/COVE OBJECTIVES:

- Raise TRL of ESTO Technologies relevant to the Earth Science Decadal Survey Missions
  - MSPI On-Board Processing (OBP) algorithm
  - Xilinx Virtex-5QV Single event Immune Reconfigurable FPGA (SIRF)
- Capture and downlink mid-resolution images of the Earth
- Educate and train the next generation of engineers in the Aerospace Industry



M-Cubed (Michigan Multipurpose MiniSat) Flight Model
Image Courtesy of U. Michigan

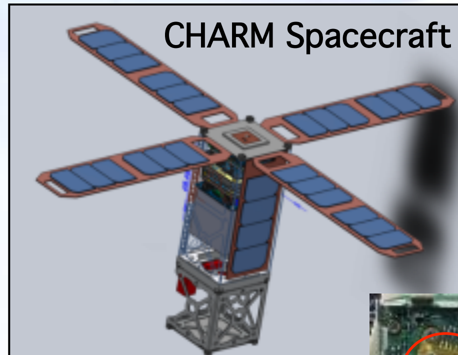
SmallSat platforms can rapidly advance the TRL of key instrument components and serve as platforms for new science observations

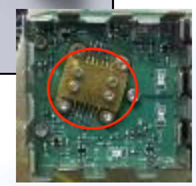
CHARM: CubeSat Hydrometric Atmospheric Radiometer Module

Spaceborne validation of Indium Phosphide (InP) MMIC radiometer
Implementation verifies subsystem for future missions (PATH and SWOT) in addition to constellation concepts

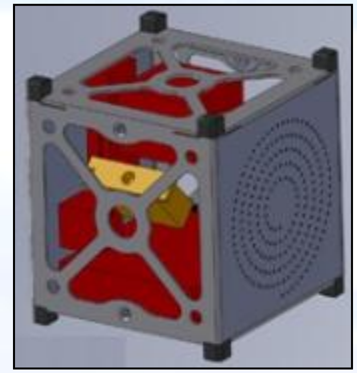
Project Objectives

- Develop a 3U CubeSat cross track scanning radiometer for water vapor and precipitation profiling
- 183 GHz radiometer payload development at JPL (1U)
- Leverage ESTO developments (IPP, ACT, AIST and IIP) for PATH (DS tier 3) and SWOT (DS tier 2)
- Demonstrate, flight qualify and calibrate:
    - Low noise InP MMIC RF front ends developed at JPL


CHARM Spacecraft

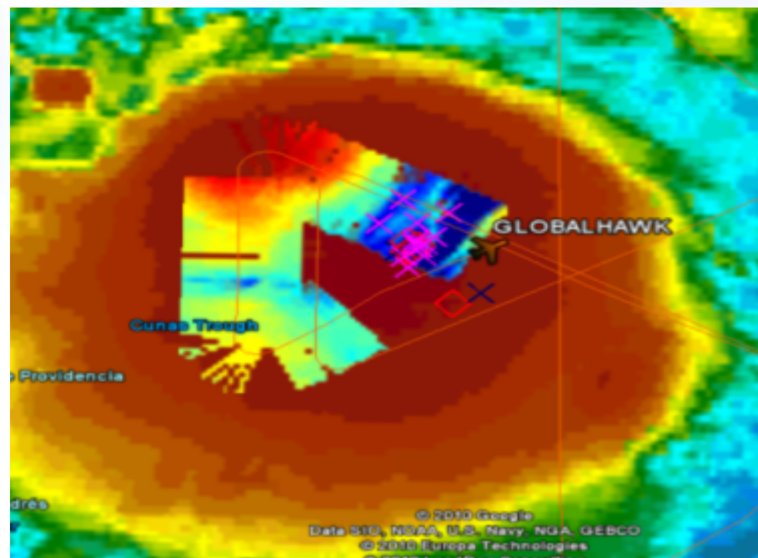

JPL 183 GHz MMIC receiver developed for PATH Approximately the size of a US quarter

Side-facing RLSA antennas with integrated MMIC receivers in 1U payload cube



Justification

- Raise the TRL (4 -> 6) of InP MMIC receiver front ends
    - –PATH (DS tier 3) and SWOT (DS tier 2)
    - – Other Earth science missions (AMSU-B, SSMIS)
- Leverage existing CubeSat developments to reduce budget and schedule risk
- Provide scientific data for atmospheric observations
- Allow for end to end development of flight-like project for personnel training



Summary

- JPL plays a significant role in NASA's Earth Science monitoring
- We are heavily involved in developing technology for the next generation of Earth Science observations through internal investments and NASA ESD's ESTO program
- Those technologies feed into our robust airborne program as well as future spaceborne measurements
- Cubesats provide one avenue to flight validate ESTO technologies
- Suborbital flights offer a fast, dependable, and *recoverable* means to flight validate those same technologies